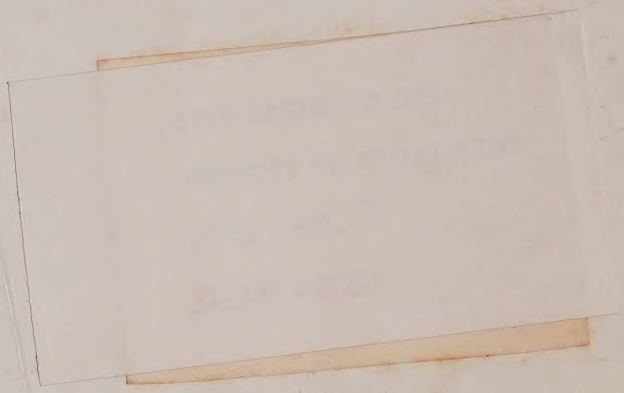
Coil winding. T. A. Gibbons

TRUE R.M.S. VOLTMETER VM 1484



SOLARTRON

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TECHNICAL MANUAL

MP MASTER
MA24437

SECTION 1

INTRODUCTION

1. The VM 1484 is an r.m.s. responding voltmeter measuring a.c. signals of up to 300 volts r.m.s. over the frequency range 10c/s - 10Mc/s. The instrument employs a patented thermocouple circuit* which eliminates the sluggish response and susceptibility to temperature changes, characteristics which normally limit the usefulness of thermocouple devices. It also enables the instrument to be used for the accurate measurement of low duty-cycle pulse trains and noise. An automatic power limiting circuit takes count of both peak and average values of signal input to provide protection against damage from overload. Facilities are provided to permit the accurate setting of the input capacitance of an RC passive probe, which can then be used in conjunction with the instrument without any degradation of specification. Square-wave signals of accurately defined amplitude are provided for the calibration of the two basic ranges.

* This circuit is the subject of letters patent granted to Weston Instruments Inc., an associate company of Solartron within the Schlumberger Group.

SECTION 2

SPECIFICATION

2. Voltage Range

12 ranges from 1mV f.s.d. to 300V f.s.d., in 1, 3, 10 sequence.
Total calibrated range -72dB to +52dB, referred to 1mW into 600 ohms.
Useful indications to 100μV.

Meter Scaling

Voltage 0-1, and 0-3.
Decibels -12 to +2dBm.

Frequency Range

10c/s - 10Mc/s.

Accuracy

±1% of f.s.d. from 50c/s - 1Mc/s.
±2% of f.s.d. from 50c/s - 2Mc/s.
±3% of f.s.d. from 50c/s - 3Mc/s.
±5% of f.s.d. from 10c/s - 10Mc/s.

Response Time

Typically 3 seconds to 1% of final reading.

Response (Parameter Sensed)

Responds to r.m.s. (heating) value of a.c. signal input.

Crest Factor Rating

(ratio of peak amplitude to r.m.s. value)
8 : 1 at f.s.d.
Proportionally greater at fractions of f.s.d.,
viz; 16 : 1 at half-scale, and 32 : 1 at quarter-scale

Input Impedance

10MΩ shunted by 25pF on the mV ranges.
10MΩ shunted by 15pF on the V ranges.

Overload Protection

Maximum d.c. input, 600V
Maximum input on mV ranges, 50V p-p
Maximum input on V ranges, 450V peak

Output

+1V at f.s.d., proportional to meter deflection. Nominal source impedance, 1000 ohms.
Access, rear panel sockets.

Noise Level

With input short-circuited approximately 40μV on 1mV and 1V ranges.

Calibrator

30mV and 1V r.m.s. square-waves, accurate to 0.5% over temperature range 0-50°C.

Temperature Rating

0-50°C.

Power Requirement

95-125V, or 190-250V, 50-60c/s and 400c/s a.c. mains.
Consumption, 24VA approximately.

Overall Dimensions and Weight

Height	$8\frac{1}{4}$ in.	(20.9 cm)
Width	5.5/8in.	(14.3 cm)
Depth	13 in.	(33 cm)
Weight	14 lb.	(6.3 kg)

Accessories Supplied

Signal lead type CX 1564, consisting of 4ft. twin coaxial, screened cable terminated with 83 UHF connector at one end, and two 4mm plugs at the other to take the provided test probes, test prods, spade terminals, or crocodile clips.

Calibrator lead type CX 1565 to connect the internally generated calibration signal to the instrument input socket.

Accessories Available

RC probe type CX 1167 incorporating a 10 : 1 resistive attenuator, and trimming capacitor.
Probe adaptor type CX 1563, for matching the CX 1167 probe to the VM 1484.

SECTION 3

INSTALLATION AND OPERATING INSTRUCTIONS

INSTALLATION

General

3. The instrument is supplied as a fully assembled and electrically set-up unit ready for installation.

   (1) Set mains voltage selector, mounted on the rear panel of the instrument, in accordance with the declared voltage of the mains supply. Arrowhead pointing to "230" for 190-250, volts mains input, or pointing to "115" for 95-125 volts mains input.

   (2) Check presence, continuity, and rating of mains fuse carried in holder on the back panel of the instrument, 250mA for 190-250 volts mains inputs, or 250mA for 95-125 volts mains inputs.

   (3) Check mechanical zero of meter, resetting by front panel adjustment screw if necessary.

   (4) Connect mains plug to mains lead, red to line (L), black to neutral (N) and green to earth (E).

OPERATION

General

4. The calibration procedure, as described in paragraph 5, need only be performed at the commencement of each period of operation, or before making a measurement that specifically requires the absolute accuracy of the instrument. In order to minimise error arising from chopper amplifier drift, whenever possible, the range selected should be such that the reading is taken between 1/3rd of f.s.d. and f.s.d (Refer explanatory note given in paragraph 9). In circumstances which require that minimum loading is applied to the signal source, the RC probe type CX 1167 can be used. (Refer paragraph 6).

Normal Calibration Procedure

5. (1) Apply mains power to instrument, check that POWER ON indicator lamp lights, and allow a minimum warm-up period of one minute.

   NOTE:
   If the measurement is to be made to the full accuracy of the instrument, the warm-up period must be extended to at least 15 minutes.

   (2) Set range selector to "30mV", and by means of the short lead supplied, connect the 30mV CAL. socket to the signal INPUT socket.

   (3) Adjust preset potentiometer RV101 (F.S.D.) for a reading of "3" (30mV) on the lower voltage scale.

   NOTE:
   RV101 is one of two, internal, preset controls mounted in the upper rear left-hand corner of the instrument. Screwdriver access is gained via the ventilation slots cut in the instrument cover. The positions and signwritten legends for these preset controls are shown in Fig. 1.

   (4) Set range selector to "300mV", and wait for three minutes before proceeding further.

   (5) Adjust preset variable resistor RV103 ("10%") for a reading of "0.3" (30mV) on the lower voltage scale.

NOTE:
Refer sub-paragraph (3) and Fig. 1 for location of RV103.

(6) The instrument is now calibrated ready for use on any of the 12 ranges.

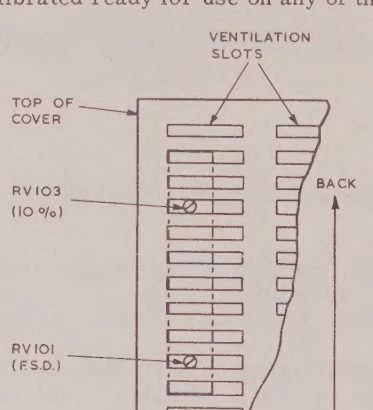


Fig. 1. Location Preset Controls.

Use of RC Probe

General

6. The input signal to the instrument can be applied via an RC probe type CX 1167, if it is necessary that the loading applied to the circuit under investigation is kept to the minimum. Provided that the probe is accurately set-up, and that the VM 1484 is subsequently calibrated at the f.s.d. and 10% f.s.d. point, in accordance with the directions given in paragraph 7, the performance of the instrument will not be affected. The RC probe type CX 1167 and the probe adaptor type CX 1563 are available as optional accessories to the VM 1484 voltmeter. The procedure necessitates the use of a high-sensitivity oscilloscope, capable of delivering externally a square-wave calibrating signal.

Method of Probe Adjustment and VM 1484 Calibration
(mV ranges (1) - (11) Volt ranges (12) - (18)).

7. (1) Insert the probe type CX 1167 into the probe adaptor type CX 1563, and connect the adaptor to the INPUT socket of the instrument.

(2) Set the instrument range selector to "100mV", and stand instrument upright on its rear panel.

(3) Remove plastic button from aperture in underside of instrument case, and connect the oscilloscope input leads to the PROBE CAL. test point thereby exposed.

(4) Set oscilloscope square-wave calibration signal to 200mV, and apply this signal to the CX 1167 probe.

(5) Adjust oscilloscope controls to give a large-scale display of the top of the square-wave.

(6) By screwdriver adjustment of the slotted brass screw at the probe tip, set the probe capacitance for optimum square-wave response.

NOTE:
It is important that this adjustment is performed with precision, if the specified accuracy of the VM 1484 is to be maintained.

(7) Disconnect oscilloscope input leads from PROBE CAL. test point, replace plastic button, and return instrument to operational position.

(8) With the instrument still switched to the "100mV" range, apply probe to the 1V CAL. output socket on the VM 1484, and adjust the F.S.D. preset potentiometer (RV101 - Fig.1) for full-scale deflection on the instrument meter.

NOTE:
The probe type CX 1167 incorporates a 10 : 1 resistive attenuator.

(9) Set range selector to "30mV".

(10) Apply probe to the 30mV CAL. output socket on the VM 1484, and adjust the "10%" preset variable resistor (RV103 - Fig.1) to obtain a reading of "0.3" (3mV) on the lower voltage scale.

(11) The instrument and probe are now set-up for measurement within the specified accuracy on any of the six mV ranges. If the instrument is to be used on the volts (V) ranges, a further calibration procedure must be carried out in accordance with the following directions.

(12) Set instrument range selector to "1V", and stand instrument upright on its rear panel.

(13) Remove plastic button from aperture in underside of instrument case, and connect the oscilloscope input leads to the PROBE CAL. test point thereby exposed.

(14) Set oscilloscope square-wave calibration signal to a level of the order of 20 volts, and apply this signal to the CX 1167 probe.

(15) Adjust oscilloscope controls to give a large-scale display of the top of the square-wave.

(16) By screwdriver adjustment of the slotted brass screw at the probe tip, set the probe capacitance for optimum square-wave response.

NOTE:
It is important that this adjustment is performed with precision, if the specified accuracy of the VM 1484 is to be maintained.

(17) Disconnect oscilloscope input leads from PROBE CAL. test point, replace plastic button, and return instrument to operational position.

(18) The instrument and probe are now set-up for measurement within the specified accuracy on any of the six volts (V) ranges.

Should it subsequently be required to return to operation on the mV ranges, the calibration procedures described in sub-paragraphs (2) to (7) must be carried out.

Input Attenuator H.F. Compensation

CAUTION

8. This procedure must only be performed if, following calibration of the "30mV" range as described in paragraph 5, a reading outside of 0.5% is obtained when the instrument is switched to the "1V" range, and the 1V calibration signal applied.

A sine-wave oscillator covering the frequency range 0-100Kc/s will be required. Though the adjustment can be made by reading direct from the VM 1484 meter scale, it is preferable that a digital voltmeter, connected at the rear panel DVM sockets, be used as the indicating device. It will be necessary to remove the upper section of the case after the withdrawal of six 4BA screws.

(1) Set oscillator to deliver a 500c/s signal, and adjust the level control for zero output.

(2) Set VM 1484 range selector to "300mV", and connect oscillator output lead to the VM 1484 INPUT socket.

(3) Gradually advance oscillator output control from zero position, until the VM 1484 registers f.s.d.

(4) Making no alteration to the oscillator frequency or output controls, set the VM 1484 range selector to "1V", and note the reading now displayed.

(5) Set oscillator to deliver a 100Kc/s signal, adjust the level control for zero output, and repeat the procedure detailed in sub-paragraphs (2) to (4) preceding.

(6) If the reading obtained on the 1V range in sub-paragraph (4) at 500c/s is the same as that obtained at 100Kc/s, apply 1V calibration signal to VM 1484 INPUT socket, and adjust variable resistor RV 209 for full-scale deflection on the meter. If the readings differ proceed as described in sub-paragraphs (7) to (9) following.

NOTE:
RV209 is the rearmost "flatpot" of a bank of seven, mounted on the edge of board No. 2.

(7) With the 100Kc/s signal still applied at the set amplitude, adjust trimming capacitor C7, with a non-metallic trimming tool, for a reading equal to that obtained in sub-paragraph (4).

NOTE: The screw threaded and slotted adjustment shaft for C7 is located at the left-hand side of the instrument, directly behind the INPUT socket.

(8) Disconnect oscillator output from VM 1484 INPUT socket and connect INPUT socket instead to the 1V CAL. socket on the VM 1484.
(9) Adjust variable resistor RV 209 for full-scale deflection on the meter.

Errors arising from Chopper Amplifier Drift

9. The d.c. output from a thermocouple is a measure of the power developed in the heater, and is therefore directly proportional to the square of the input voltage driving current through the heater. The full-load output from a thermocouple of the type employed in the VM 1484 is of the order of 7000μV, which output as a result of the square-law relationship between input and output voltages, will be 770 μV at one third of full-load, and 70 μV at one tenth of full-load. Therefore, full-scale meter deflection will occur with a thermocouple output of 7000 μV, and one third and one tenth full-scale deflections with thermocouple outputs of 770 μV and 70 μV respectively. Thus a drift of 7 μV in the chopper amplifier would represent an error of 5% of reading at one tenth f.s.d., and an error of less than 0.5% of reading at one third of f.s.d. It is therefore recommended that whenever possible, the range selected for any measurement is such that the reading is taken between the 1/3 f.s.d. and f.s.d. points of the meter scale.

Measurement of High Crest-Factor Waveforms

10. The crest factor of a waveform is, by definition, the ratio of the peak value to the r.m.s. value. The crest factor rating of an r.m.s. voltmeter is a measure of its ability to read accurately the r.m.s. values of low duty-cycle pulse trains and waveforms of indeterminate shape. The crest factor of a low duty-cycle pulse train of the nature of those illustrated in Fig. 2, can by calculus be shown to be equal to $\sqrt{\frac{t_2}{t_1}}$. The VM 1484, which has a specified crest factor at f.s.d. of at least 8 : 1, is therefore able to measure accurately at full-scale the r.m.s. value of any pulse train in which the ratio of t_2 to t_1, does not exceed 64. The pulse train measurement potential of the VM 1484 can best be appreciated by consideration of the waveforms shown in Fig. 2. That at (a) has a crest factor of $\sqrt{8}$ and that at (b) a crest factor of 8, both of which, can therefore be measured at full-scale deflection to specified accuracy. When the crest factor of the waveform exceeds 8, the VM 1484 overload protection circuits come into operation to limit the power dissipated in the signal thermocouple, as a result of which, readings taken at full-scale deflection are outside the specified accuracy. However, pulse trains of crest factor greater than 8 can be measured to specification provided that the reading is taken within the confines of a reduced linear sector of the scale. The upper limit of this linear scale sector for a waveform of known crest factor can be established by dividing the rated f.s.d. crest factor of 8, by the crest factor of the waveform under investigation. Thus for a signal having a crest factor of 16, this upper limit will occur at half-scale $(\frac{8}{16})$ deflection, and having

regard to the drift considerations mentioned in paragraph 9, the specified accuracy of measurement will only be attained if the reading is taken between 1/3rd f.s.d. and half-scale. Generally, the crest factor of the signal waveform will be capable of determination by inspection on an oscilloscope, or if the signal originates from a pulse generator, by reference to the generator period and duration controls. In circumstances where these methods cannot be applied, the presence of overload due to excessive crest factor can be established by initially selecting a VM 1484 range which gives a deflection approaching full-scale, and then proceeding to the next range up, and checking that the same reading is obtained. Should the second reading be greater than the first, it can be assumed that the instrument was overloaded on the first selected range.

11. The mathematical derivation of the expressions for the r.m.s. value and crest factor of a typical pulse train (Fig. 2a) follow.

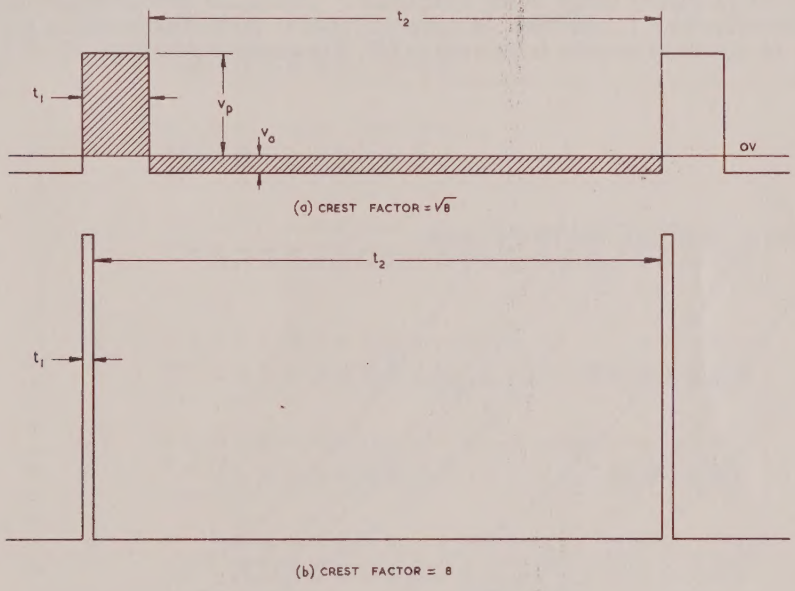


Fig. 2. Typical Pulse Trains.

V_p = Positive Peak Voltage
V_a = Negative Peak Voltage
} Relative to mean level over a whole cycle.

The r.m.s. value of the waveform is:-

$$V_{r.m.s.} = \sqrt{\frac{1}{t_1 + t_2}\left(\int_o^{t_1} V_p^2 \, dt + \int_o^{t_2} V_a^2 \, dt\right)}$$

$$= \sqrt{\frac{V_p^2 t_1}{t_1 + t_2} + \frac{V_a^2 t_2}{t_1 + t_2}} \qquad 1$$

but $V_p t_1 = V_a t_2$

$$V_a = \frac{V_p t_1}{t_2} \qquad 2$$

Substitute 2 in 1,

$$V_{r.m.s.} = \sqrt{V_p^2 \frac{t_1}{t_2}} = V_p \sqrt{\frac{t_1}{t_2}}$$

$$\text{Crest factor} = \frac{V_p}{V_{r.m.s.}} = \sqrt{\frac{t_2}{t_1}}$$

Note that had the d.c. term been included the crest factor would become:

$$\sqrt{\frac{t_1 + t_2}{t_1}}$$

Measurement Errors in Rectangular Waveforms of High Crest Factor

12. High crest factor rectangular waveforms will include high order harmonic components outside the specified frequency range of the instrument. The typical percentage error introduced by attenuation within the r.f. amplifier is given in Table 1, which was complied from calculations based on the equations derived in paragraph 13. The results are presented in graphical form in Fig. 3.

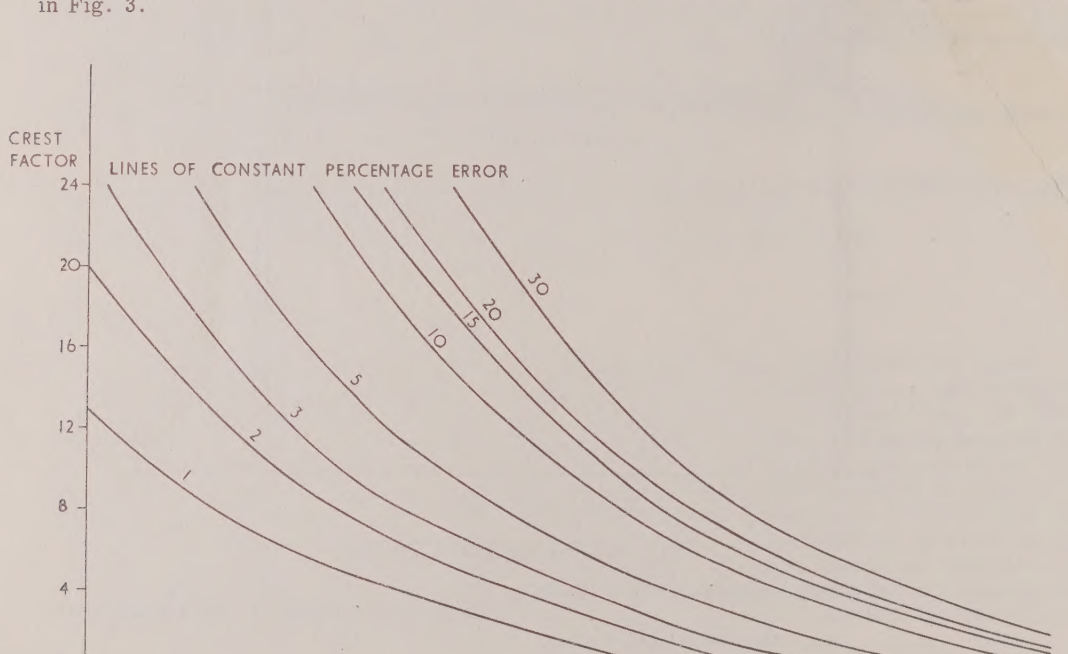


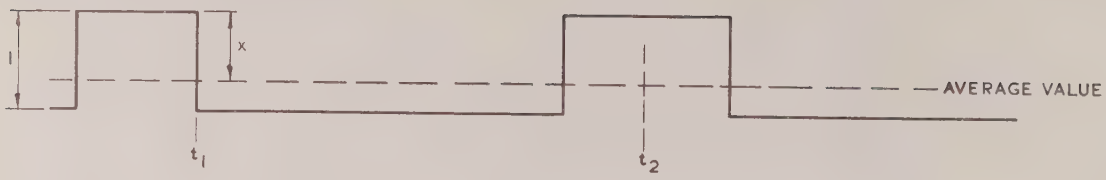
Fig. 3. Constant error curves, frequency against Crest Factor
True rectangular Waveforms.

TABLE 1 .

TYPICAL PERCENTAGE ERROR IN PULSE TRAIN MEASUREMENTS

	PULSE REPETITION FREQUENCY.													
Crest Factor.	10Kc/s	50Kc/s	100Kc/s	500Kc/s	1Mc/s	2Mc/s	3Mc/s	4Mc/s	5Mc/s	6Mc/s	7Mc/s	8Mc/s	9Mc/s	10Mc/s
1	0.2	0.3	0.4	1.2	2.2	3.6	4.9	6.1	7.1	8.6	9.7	10.4	11.0	11.5
2	0.2	0.3	0.4	1.7	3.0	5	6.8	8.3	9.9	12.5	15	17.3	20.8	23.8
3	0.2	0.4	0.7	2.7	4.5	7.4	11.1	15.7	20.6	25.7	30	33.7	37.9	41.5
4	0.2	0.6	1.0	3.8	6.4	12.3	20.2	27.7	34	39.5	43.9	47.4	51.1	54.3
5	0.2	0.8	1.5	5.2	8.9	20.2	30.8	38.9	45	50	54	57.1	60.2	62.9
6	0.3	1.1	1.9	6.5	13.2	28.9	40.1	47.8	53.3	57.8	61.2	63.9	66.6	68.8
7	0.3	1.4	2.4	8.3	18.9	36.9	47.6	54.7	59.6	63.6	66.6	68.9	71.2	73.2
8	0.4	1.7	3.0	11.1	25.1	43.6	53.7	60.0	64.5	68	70.7	72.7	74.8	76.5
9	0.5	2.1	3.6	14.7	31.1	49.3	58.5	64.3	68.4	71.5	73.9	75.7	77.5	
10	0.6	2.4	4.2	18.9	36.6	54.0	62.5	67.8	71.5	74.3	76.5	78.1	79.8	
11	0.7	2.8	4.8	23.3	41.5	58	65.9	70.7	74	76.6	78.6			
12	0.9	3.2	5.4	27.7	45.9	61.4	68.6	73.1	76.2	78.6	80.4			
13	1.0	3.6	6.0	31.9	49.7	64.2	71.0	75.2	78					
14	1.1	4.0	6.7	35.8	53	66.7	73.1	76.9	79.6					
15	1.3	4.5	7.4	39.3	56	68.9	74.8	78.5	80.9					
16	1.4	5.0	8.4	42.6	58.6	70.8	76.4	79.8	82.1					
17	1.6	5.4	9.6	45.6	61	72.5	77.8	81	87.2					
18	1.7	5.9	11.0	48.4	63.1	74	79.0	82	84.1					
19	1.9		12.5	50.9	65	75.4	80.1	83	84.9					
20	2.0		14.2	53.2	66.7	76.6	81.1	83.8	85.7					
21	2.2		16.0	55.3	68.2	77.7	82	84.6	86.4					
22	2.3		17.9	57.2	69.7	78.7	82.8	85.3	87					
23	2.5		19.8	59.0	71	79.7	83.6	85.9	87.6					
24	2.7		21.8	60.7	72.2	80.5	84.2	86.5	88.1					

Fourier Analysis of Pulse Train.



13. $F(t) = \frac{1}{2}a_o + \sum_{n=1}^{\infty} (a_n \cos n\omega t + b_n \sin n\omega t)$

this simplifies to

$$F(t) = \sum_{n=1}^{\infty} a_n \cos n\omega t.$$

as $b_n = 0$ and $a_o = 0$.

$$a_n = \frac{\omega}{\pi}\int_0^{\frac{2\pi}{\omega}} F(t) \cos n\omega t.\ dt. \qquad \frac{\omega}{2\pi} = \frac{1}{t_2}$$

$$= \frac{\omega}{\pi}\left[\int_0^{t_1} x \cos n\omega t.\ dt - \int_{t_1}^{t_2-t_1} (1 - x) \cos n\omega t.\ dt + \int_{t_2-t_1}^{t_2} x \cos n\omega t.\ dt\right]$$

$$= \frac{1}{n\pi}[-\sin n\omega(t_2-t_1) + \sin n\omega t_1 + x \sin n\omega t_2]$$

$$= \frac{2 \sin n\omega t_1}{n\pi} = \frac{2 \sin \frac{2n\pi t_1}{t_2}}{n\pi}$$

and in the $\frac{\sin\theta}{\theta}$ form $a_n = \dfrac{4t_1}{t_2} \dfrac{\sin \frac{2n\pi t_1}{t_2}}{\frac{2n\pi t_1}{t_2}}$

But a_n must be modified by a factor $Kn\omega$, an attenuator factor due to the R.F. amplifier.

Thus $a_n = \dfrac{4t_1}{t_2} \dfrac{Kn\omega \sin \frac{2n\pi t_1}{t_2}}{\frac{2n\pi t_1}{t_2}}$

If t_1 and t_2 are expressed in terms of crest factor C, it can be proved that

$$C = \sqrt{\frac{t_2 - 2t_1}{2t_1}}$$

or $\dfrac{1}{1 + C^2} = \dfrac{2t_1}{t_2}$

Thus $a_n = 2C.\ Kn\omega.\ \dfrac{\sin Cn\pi}{Cn\pi}$

Now R.M.S. $= \sqrt{a_1^2 + a_2^2 \ldots\ldots a_n^2}$

Thus the r.m.s. value of the waveform may be calculated knowing $Kn\omega$.

SECTION 4

PRINCIPLES OF OPERATION

Refer Fig. 4.

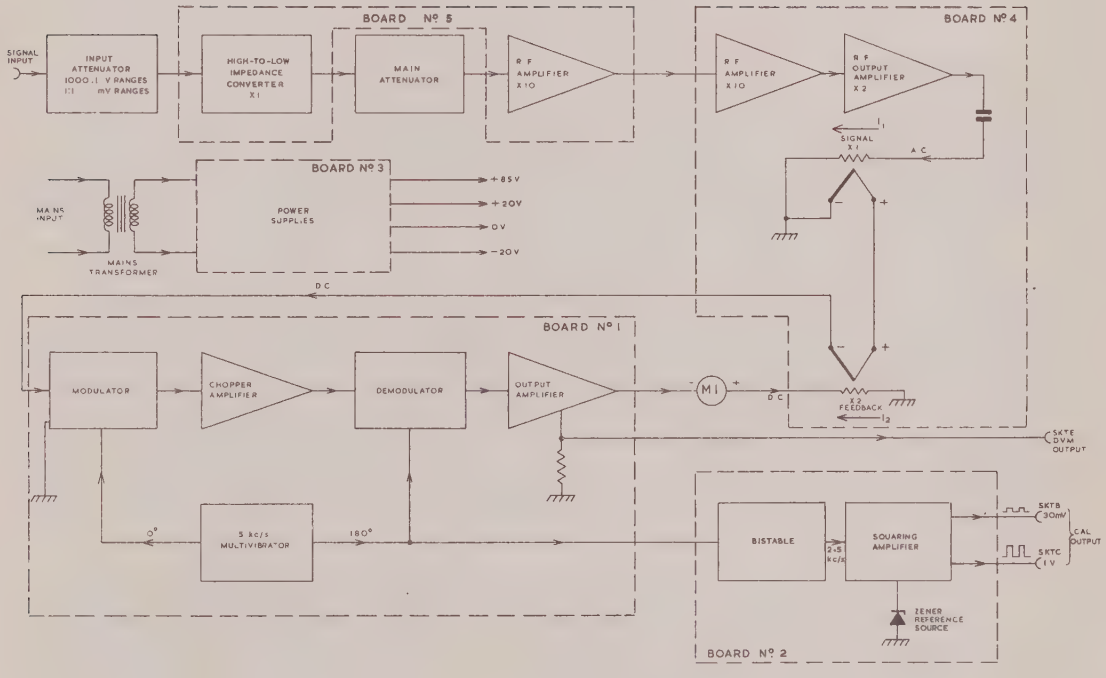


Fig. 4. VM 1484 Block Schematic Diagram.

1. Input signals of one volt or more are attenuated in the ratio of 1000 : 1 by the h.f. compensated input attenuator. Signals of less than one volt are applied direct to the impedance converter stage. This consists of a unity gain cathode-follower, employing a Nuvistor valve, which arrangement presents a high impedance to the input circuitry, whilst providing a low source impedance to the main attenuator. The cathode-follower is "boot-strapped" to maintain the input impedance at a high value. The main attenuator consists of a 50dB resistive divider switched by the range selector in 10dB steps. Two stages of r.f. amplification are provided prior to the r.f. output amplifier, which drives an a.c. current proportional to the heating (r.m.s.) value of the signal input through the heater of the signal thermocouple X1. The outputs of the matched signal and feedback (X2) thermocouples are connected in polarity opposition across the input to the high gain chopper amplifier in a self-balancing bridge arrangement. The application of an a.c. input voltage will cause an a.c. current i_1 to flow through the heater of X1, thus developing in the couple a d.c. voltage directly proportional to the r.m.s. value of the a.c. input power. This d.c. voltage produces an unbalance signal at the input of the chopper amplifier, which passes an increasing d.c. current i_2 through the meter and the heater of the feedback thermocouple X2. When the heating value of the d.c. current i_2 equals that of the a.c. current i_1, the signal input to the chopper amplifier will be reduced to mean zero, and

the d.c. drive current to X2 heater will be held at the value required to maintain balance. Since this current will pass also through the meter, the deflection registered will be proportional to the heating value of the a.c. current i_1, which in turn is a function of the r.m.s. value of the a.c. input power. The thermocouples are protected against burn-out by restricting the power dissipation in the signal thermocouple heater in accordance with the average level of applied signal voltage. This method of overload protection enables the r.f. output amplifier to handle signals having peak amplitudes some eight times greater than the full-scale r.m.s. value, thus permitting the accurate measurement of high crest-factor waveforms. Square-wave calibration signals of 30mV and 1 volt r.m.s. at 2.5kc/s are derived from a bistable-driven squaring amplifier, the output amplitude of which is stabilised by a zener reference source. The bistable is triggered by one output of the 5kc/s symmetrical multivibrator, which also drives the modulator and demodulator stages of the chopper amplifier.

SECTION 5

CIRCUIT DESCRIPTION

Input Attenuator (Fig. 15).

1. On the six mV ranges (positions 1-6 of the range selector SA), the input signal is applied unattenuated to the impedance converter stage via switchbanks SA1R, SA2R, and capacitor C5. On the six V ranges (positions 7-12 of the range selector SA), the input signal is attenuated in the ratio of 1000 : 1 by the resistive voltage divider R1, R2. H.F. compensation is effected by trimmer capacitor C7 which is adjusted for optimum response at a frequency of 100Kc/s.

Impedance Converter Stage (Fig. 16)

2. The function of this stage is to present a high input impedance to the signal being measured, and to convert this high impedance to a low output impedance suitable for driving the succeeding transistor amplifiers via the main attenuator. The stage consists of a Nuvistor value V501, connected as a cathode-follower to provide unity gain. The input signal is a.c. coupled to the grid of V501, the operating potential of which is established by the zener diode MR501 drawing current from the +20 volts rail via resistor R501. The cathode potential is tied to the grid potential by means of a "bootstrap" circuit to ensure that the stage input impedance is maintained at a high value. For this purpose, transistor VT501 is driven on its base by the voltage developed at the anode of V501, which voltage will be 180° out of phase with the input signal applied at V501 grid.

   The emitter/collector path of VT501 is connected in series with the cathode of V501 to provide a resistance which will vary with changes in input signal. Assuming a positive input to the grid, the anode current will increase and the anode voltage will move negatively to reduce the current passed by VT501, and hence increase the effective resistance presented by that transistor to V501 cathode current. The overall effect of the increased valve current and cathode resistance is to ensure that the cathode voltage closely follows the grid voltage. Conversely, the decreased anode current and effective cathode resistance arising from a negative signal input will cause a proportionate drop in V501 cathode potential. Signal output to the main attenuator is taken from the cathode of V501 via terminal 84. The heater of V501 is energised by a regulated d.c. supply to prevent the introduction of mains hum.

Main Attenuator (Fig. 15).

3. The main attenuator consists of a resistive voltage dividing network R6-R12, switched by bank SA3F of the range selector to provide six degrees of attenuation in 1, 3, 10, 30, 100 and 300 sequence, (10 dB steps). Standard 1% tolerance resistors are employed for the attenuator elements, the final adjustment for accuracy being provided by ranging potentiometers associated with the output stage of the instrument. The attenuated signal is coupled via capacitor C9 and terminal 87 to the input r.f. amplifier.

Input R.F. Amplifier (Fig. 16).

4. The input signal is applied to the base of the emitter follower VT502, which is included to in-

crease the input impedance of the succeeding stage built round transistor VT503. Diodes MR502 and MR503 are connected in the base circuit of VT502 to provide some measure of temperature compensation. Transistor VT503 functions as a driver stage for the r.f. amplifier proper (VT504), which is connected as a virtual earth amplifier. The drive current provided by VT503 is defined by the value (68 ohms) of the emitter resistance R521 at approximately 15mA/volt input to VT503, which resistance is in effect the input resistor to the virtual earth amplifier VT504. The feed-back resistor R522 connected between collector (output) and base (input) to VT504 has a value of 750 ohms to give the virtual earth amplifier an overall gain approximately 11, $(\frac{750}{68})$. The value of resistor R528, connected in parallel with the feed-back resistor, is selected on test to give the precise gain required of the amplifier. Variable resistor RV501 provides a preset adjustment for accurately setting the operating condition of the virtual earth amplifier. Zener diode MR504 functions as a d.c. coupling and level changing device. Capacitors C522, C517, and C516/R517 provide h.f. compensation. Output to the succeeding stages on board No. 4 is taken from the collector of VT504 via terminal 90 and coupling capacitor C10 (Fig. 15).

Intermediate R.F. and Output Amplifiers (Fig. 17).

5. Two cascaded r.f. amplifiers are employed, having nominal gains of 10 and 2, the output from the last of which feeds a voltage-operated current amplifier driving a.c. current into the signal thermocouple via a complementary transistor pair. The first r.f. amplifier employs an emitter follower (VT401) input stage, a driver (VT402) and a virtual earth amplifier (VT403) all of the same design as that already described in paragraph 4 for the input r.f. amplifier. The gain is defined at approximately 10 by the ratio of the value of the feedback resistor R411 to that of the input resistor R408. The second r.f. amplifier consists of an emitter-follower (VT404) input stage, driver (VT405), and virtual earth amplifier (VT406), the output from which drives a complementary transistor (VT408, VT409) via an emitter-follower (VT407). Overall a.c. feedback from the output of the complementary pair to the input of the virtual earth amplifier VT406 is applied via capacitor C418 and resistor R426, the ratio of the value (330 ohms) of the feedback resistor to that (150 ohms) of the input resistor R423 defines the stage gain at approximately 2. D.C. feedback is applied between the collectors of VT406 and VT405 via, resistors R436 and R446, to stabilise the d.c. potential of VT407 emitter. The function of the complementary pair VT408, VT409, is to drive a.c. current through the heating element of the signal thermocouple X401.

   On a positive-going input to C414 from the emitter of VT407, diode MR408 will be reverse-biased, and as a result the base of the n.p.n. transistor VT408 will be carried positively by the +20 volts potential applied via R434. Transistor VT408 will now pass current to reduce its collector potential, and capacitor C421 will discharge to this lowered potential through VT408, R442, R445, and X401 heating element. In a similar manner, a negative-going input drive will cause C422 to pass a discharge current through VT409, R443, R445, and X401 heating element.

Overload Protection, (Fig. 17)

6. The overload protection circuitry is incorporated in the output amplifier VT408, VT409, which drives an a.c. current through the heater of the signal thermocouple X401. Since the input to the output amplifier is a.c. coupled, that section of the amplifier employing the n.p.n. transistor VT408 will operate on that portion of the signal positive to the average value of the input signal. Conversely, that section of the amplifier employing the p.n.p. transistor VT409 will operate on the negative portion. The signal thermocouple has to be protected against excessive power dissipation arising from both d.c. and a.c. overloading signal inputs. The operation of the overload system is best understood by consideration of either section of the output amplifier. The following description has been written with specific reference to that section of the amplifier driven by VT408, but in principle is equally applicable to the other amplifier section employing VT409.

7. D.C. protection is necessary to avoid thermocouple damage being caused by the application of an a.c. signal superimposed on a high-level d.c. component, or surge currents produced when the instrument is switched on or off.

   Assuming that a positive step voltage is applied to the instrument, the base of VT408 will move in a positive direction causing the transistor to pass more current and thus lower its collector

potential. The maximum swing in collector potential is defined at 10 volts, i.e., from +20 to +10 volts, by the emitter potential. Prior to the application of the input signal, coupling capacitor C421 will be charged to the potential (+20 volts) of the positive supply rail. When the collector potential falls, capacitor C421 must discharge to the new level through R442, R445, and X401 heater. The maximum power that can be dissipated in the thermocouple heater during the discharge period is limited to a safe value by the simple expedient of restricting the energy stored in the coupling capacitor, i.e., by choice of a suitable value for that component. For the same reason, the energy dissipated in the thermocouple heater by charge and discharge currents produced when switching the instrument on and off cannot exceed the limiting value.

8. A.C. overload protection is achieved by limiting the collector potentials of drive transistors VT408 and VT409 in inverse proportion to the average value of the input signal. Thus the available swing of collector voltage for a wave form of high crest factor will be greater than that available on a signal of low crest factor. By this method of overload protection, the output amplifier is allowed to operate over the wide dynamic range essential for the measurement of wave forms having a high peak/r.m.s. ratio. Assume that a rectangular wave form of 1 : 1 mark/space ratio (unity crest factor) is applied to the output amplifier. As VT408 base potential is carried in a positive direction, the collector potential will fall by a proportionate amount. The coupling capacitor C421 will now commence to discharge through R442 (27 ohms), R445 (30 ohms), and X401 (90 ohms) at a rate determined by a time constant of 147C. When VT408 base is taken negative, the collector potential will rise sharply towards its original level, which it will fail to attain by an amount equal to the drop in voltage across C421 during the discharge period. The coupling capacitor C421 will now commence to re-charge towards +20 volts through R441 (3, 000 ohms) and X401 (90 ohms) at a rate determined by a time constant of 3090C. Since the rate of charge is some 20 times slower than the rate of discharge, the capacitor will replenish only a fraction of the charge depletion before it is returned to the discharging condition by the next positive-going edge of the signal waveform. This process will be repeated on each successive cycle of the signal, forcing the mean collector potential lower and lower along the exponential curve governing the discharge until ultimately the collector potential stabilises at that value at which the charge lost during the discharge period is equal to that gained during the charge period. Thus, with a signal of unity crest factor, the available collector voltage swing is limited to the difference between the quiescent emitter potential and the final settling potential of the collector. When the input signal is of high crest factor, the charge period is so much longer than the discharge period that the collector potential is allowed to closely approach, or even attain the maximum level, according to the repetition frequency of the pulse train.

Chopper Amplifier (Fig. 18).

9. The outputs from the signal (X401) and feedback (X402) thermocouples are connected in series across the amplifier input in such sense that the signal applied to the amplifier is the difference between the e.m.f.'s developed by the couples. Since no two thermocouples will produce identical outputs, the thermocouple delivering the higher e.m.f. of the two is always employed for the feedback couple connected across terminals 11 and 12. The effective output from this couple is then reduced to equality with that of the signal couple by adjustment of the potential divider RV101, R101. The input chopper transistor VT101 is driven on its base by the 5kc/s square-wave output from a multivibrator to convert the d.c. difference signal to a proportional a.c. signal. The negative offset potential developed across the chopper transistor is backed-off by the positive potential developed across resistor R110, as determined by variable resistor RV103. Since the magnitude of the offset potential will vary with temperature, compensation is applied from a variable potential source (RV102) via thermistor X101. The a.c. signal is applied to a three stage direct-coupled amplifier employing transistors VT102, VT104 and VT106. Coupling between amplifying stages is effected by emitter-followers VT103 and VT105 to neutralise drift arising from temperature variations. An emitter-follower (VT107) provides output to the synchronous demodulator VT108, which chops the signal at 5kc/s to convert the a.c. voltage to d.c. The output amplifier consists of a long-tailed pair VT113/VT114 feeding the meter drive stage VT116 via an emitter-follower VT115.

Meter Drive and Calibration Circuits (Fig. 5)

10. An integrated diagram of the meter drive and calibration circuits is given in Fig. 5. The meter M1 is connected in the collector circuit of VT116, in series with the heating element of the feedback thermocouple X402 and the current limiting resistor R449. The instrument is set-up on

the basic 1mV range by passing a d.c. current of 5mA through the heater element of the signal thermocouple X401, and adjusting the equalising potentiometer RV101 until a current i, of the same (5mA) value flows through the heating element of the feedback thermocouple X402. Since the meter M1, which has an internal resistance of 80 ohms nominal and an f.s.d. of 5mA, is shunted by resistor R15 (390 ohms), only some 4.1 mA will flow through the meter which will not register the full-scale deflection required for a correct reading. Accordingly, a current i_2 is fed into the meter line via variable resistor RV203 and R212, the magnitude of this current being set by RV203 to that value required to raise M1 deflection to full-scale. The accuracy on the 3, 10, 30, 100, and 300mV ranges is set in a similar manner by adjustment of RV204 to RV208 inclusive. Correct tracking between the mV and V ranges is obtained by adjustment of RV209 on a one volt input.

D.V.M. Output (Fig. 5)

11. The positive d.c. voltage developed across resistors R165 and RV106 by the meter current is extended to the rear-mounted socket SKTE for the purpose of driving a digital voltmeter. This voltage, which bears a linear relationship to meter deflection, is set by adjustment of RV106 to precisely one volt when meter M1 is registering f.s.d. (1 or 3.162).

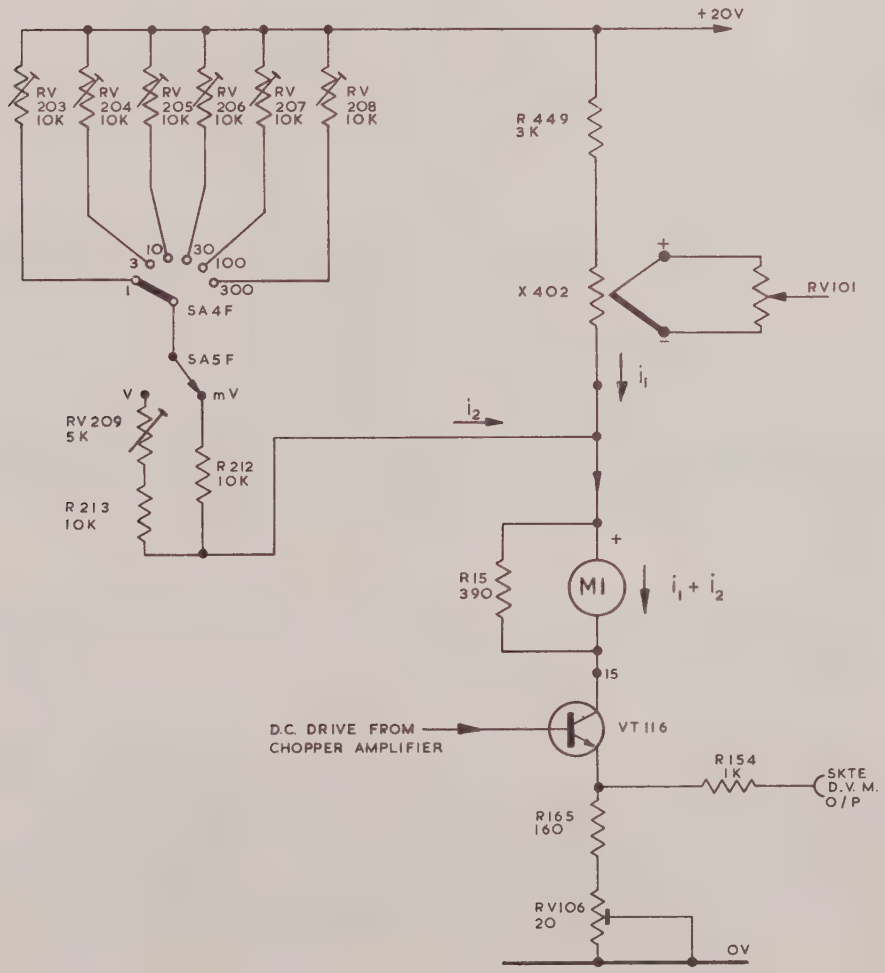


Fig. 5. Meter Drive, Calibration, and D.V.M. Output circuits.

Calibrator Circuit (Fig. 19)

12. A bistable consisting of transistors VT201 and VT202 is triggered by the output of the 5kc/s multivibrator (Fig. 18) via terminal 36 and capacitor C201. Output is taken from the collector of VT202 at a pulse repetition frequency of 2.5kc/s, to drive transistor VT203. The amplitude of the square-wave signal developed in VT203 collector circuit is stabilised at -5.6 volts by the zener diode MR201. This signal is divided-down in the resistive dividers R206, R207, RV201 and R208, R209, RV202, to provide square-wave calibration signals having r.m.s. values of 30mV and 1 volt respectively at the panel-mounted sockets SKTB and SKTC.

POWER SUPPLY CIRCUITS

General.

13. These circuits provide the +85volts, +20volts, and -20volts regulated supplies required for the operation of the instrument. With the exception of the mains switch, mains fuse, mains voltage selector panel, mains transformer, and certain smoothing capacitors, all components are mounted on board No. 3.

Mains Input Circuit (Fig. 20)

14. The mains transformer T1 is provided with a split primary winding capable of parallel or series connection to accommodate mains inputs with the range 95-125volts or 190-250volts. Change-over between ranges is performed by adjustment of the mains voltage selector panel MSP1. The transformer has three secondary windings which are applied to the stabilising circuits mounted on board No. 3.

+20 Volts Stabilised Supply (Fig. 20)

15. The 23.5 volts r.m.s. output appearing across transformer terminals 5 and 6 is applied to a bridge rectifier MR301-MR304. The smoothing capacitor (C3) for this supply is mounted external to the board at terminals 47 and 50. The stabilising circuit consists of a series control element (VT301) which is driven on its base by an amplified error signal derived from the comparison of a voltage taken from a sampling chain connected across the supply output terminals, with a reference voltage. The sampling chain consists of R307, RV301, R308, the signal output from which is applied to the base of VT304. The emitter of this transistor is stabilised at approximately +6.2 volts by the reference zener diode MR7, and an amplified error signal is developed at VT304 collector. One further stage of amplification is provided by VT303, which provides base current to the emitter follower VT302 driving the series element proper (VT301). Variable potentiometer RV301 enables the level of the supply to be set to +20 volts.

-20 Volts Stabilised Supply (Fig. 20)

16. This supply is derived from a similar circuit to that employed for the +20 volts supply. 24 volts r.m.s. is taken from transformer terminals 7 and 8. Level setting is performed by variable potentiometer RV302.

+85 Volts H.T. Supply (Fig. 20)

17. 113 volts r.m.s. is taken from transformer terminals 9 and 10, and applied to the bridge rectifier MR320-MR323. Stabilisation is effected by a shunt regulator element (Nuvistor valve V301), driven on its grid by the output of a two-stage transistor amplifier (VT311, VT312). The sample signal is picked-off the sampling chain by the wiper of RV303, and applied to the base of VT311, whose emitter is referred to earth. The resultant error signal developed at the collector of VT311 is amplified in VT312 to drive the grid of the shunt regulator V301. The supply is set to the required level (approximately +85 volts) by adjustment of RV303.

Valve Heater Supplies

18. The heaters of Nuvistor valves V301 and V501 (board No. 5) are connected in series across the +20 volts stabilised rail. The excess voltage (7.4V) is dropped across resistor R327.

SECTION 6

MAINTENANCE

DISMANTLING DIRECTIONS

Removal of Case

1. The instrument case is made in two separable sections, an upper U-shaped cover, and a bottom tray.

   (1) Withdraw two Phillips type screws from top of case, one to the front and one to the rear of the carrying handle.

   (2) Withdraw two Phillips type screws from each side of the instrument case.

   (3) Lift upper cover clear of chassis.

   (4) To remove bottom tray, withdraw two Phillips type screws from the front edge of the underside of the case, and one Phillips type screw from the centre of each of the rear feet. Remove bottom tray with front feet attached.

Access to Printed-Circuit Boards

2. Printed-circuit board nos. 1 and 3 are hinge-mounted in the vertical plane, at the left and right-hand sides of the instrument respectively. These boards can be swung-out through 90° after removal from each of two Phillips type screws from the forward corners. Release of the left-hand board will also provide access to board No. 2. Board No. 4 is mounted across the two lower chassis members, and is enclosed by a two-section metal screening box. To remove the screen, place chassis upside-down, and withdraw four screws from the corners of the box. Lift-off flat bottom cover of screen, and withdraw box section through that side of the chassis at which board No. 3 is mounted.

SETTING-UP AND TEST PROCEDURE

General

3. The following procedure is basically the production test to which all VM 1484 True R.M.S. Voltmeters are subjected prior to despatch. It is given to enable the user of the instrument to confirm its performance should this at any time become suspect, and to make any adjustments that may be necessary. It is assumed that both the upper and bottom covers and screening box have been removed from the instrument following the directions given in paragraph 1.

Test Equipment Required

4. The listed items of test equipment will be required if the procedure is to be carried out in its entirety. The type numbers of suitable Solartron equipments are given in brackets.

   (1) Two digital voltmeters, 2.5uV resolution (LM 1420.2).
   (2) Sine-wave oscillator, 25c/s-10Mc/s (CO 546.2 and DO 905).
   (3) Variac
   (4) D.C. power supply, 5V. (AS 1164, AS 1410).
   (5) Oscilloscope (CD 1400)
   (6) Pulse generator, 30V r.m.s., 2.5kc/s (GO 1101.2).
   (7) Attenuator, 0-60dB, 100Mc/s. (B1200).
   (8) A.C. Calibrator.
   (9) 50Ω non-inductive resistive termination.
   (10) Variable resistance, 10-turn, value 1000Ω.
   (11) Fixed resistor, value 330Ω.
   (12) Close tolerance resistance (0.1%) of approximately 1000Ω.
   (13) Thermocouple Monitor Unit, as per Fig.6.

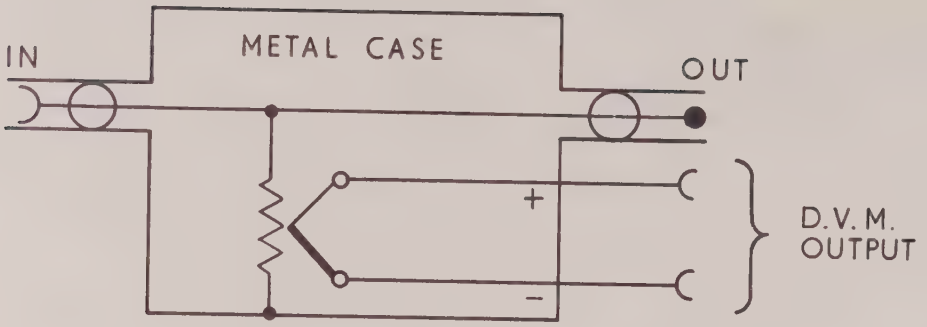


Fig. 6. Test Rig, Thermocouple Monitor Unit.

Test Procedure

Set Potentials of Supply Rails.

5. All components are mounted on board No. 4 unless otherwise stated.

(1) Check that mains voltage selector is set to "230".
(2) Connect a link across the heater of thermocouple X401, i.e. between the junction of C421/C422 and pin 67 (0 volts).
(3) Connect VM 1484 to an a.c. mains supply of 240V ± 5V. Set range selector to "300mV", short INPUT socket to earth, and set POWER switch to ON.
(4) Connect digital voltmeter across the +20V (pin 66) and 0V (pin 67) rails, and, if necessary adjust RV301 (board No. 3) for a digital voltmeter reading of 20V ± 100mV. Check that the hum and noise level on the rail does not exceed 240μV.
(5) Connect digital voltmeter across the -20V (pin 68) and 0V (pin 67) rails, and, if necessary, adjust RV302 (board No. 3) for a digital voltmeter reading of -20V ± 100mV. Check that the hum and noise level on the rail does not exceed 250μV.
(6) Connect digital voltmeter across resistors R505 and R506 (board No. 5), and adjust RV303 (board No. 3) for a digital voltmeter reading of 9.6 ± 100mV.

NOTE: R505 and R506 are floating at a potential some 70V above earth.

(7) Check that the hum and noise level on the +85V (Nominal) rail does not exceed 280μV.

Set D.C. Conditions of R.F. Amplifiers.

6. All components are mounted on board No. 4 unless otherwise stated.

(1) Connect digital voltmeter between the junction of R520/R522 (board No. 5) and pin 89 (0 volts) and note the reading on the digital voltmeter.
(2) Connect digital voltmeter between the junction of R522/R525 and pin 89 (0 volts) (board No. 5), and adjust RV501 (board No. 5) to obtain a digital voltmeter reading within ± 100mV of that noted in sub-para. (1).
(3) Connect digital voltmeter between the junction of R410/R411 and pin 67 (0 volts), and note the reading on the digital voltmeter.
(4) Connect digital voltmeter between the junction of R411/R412 and pin 67 (0 volts), and adjust RV401 to obtain a digital voltmeter reading within ± 100mV of that noted in sub-para. (3).
(5) Connect digital voltmeter between the junction of R425/R446 and pin 67 (0 volts), and note the reading on the digital voltmeter.
(6) Connect digital voltmeter between the junction of R433/C414 and pin 67 (0 volts), and adjust RV402 to obtain a digital voltmeter reading within ± 100mV of that noted in sub-para. (5).
(7) Connect digital voltmeter across R444, and adjust RV403 for a digital voltmeter reading of 1V ± 20mV.
(8) Connect digital voltmeter between the junction of R442/R443 and pin 67 (0 volts), and check that the digital voltmeter registers within ± 100mV of 10V.
(9) Remove short from across X401 heater.
(10) Set VM 1484 POWER switch to "off", and refit box-section screening cover to board No. 4.
(11) With the VM 1484 in its normal operational position, set mechanical zero on meter.

Set Thermocouple Linearity.

CAUTION

7. When carrying-out this procedure do not, at any time, switch on the VM 1484 when the current source is applying current to the thermocouple heater. Failure to observe this precaution may cause the thermocouple to burn out.

(1) Set VM 1484 POWER switch to "off".
(2) Wire up the current source in accordance with the circuit given in Fig.7, using test equipment items (4), (10), (11) and (12). The 330 ohms stopper resistance must be connected as close as possible to the "high" end (junction of C421/C422) of thermocouple X401.

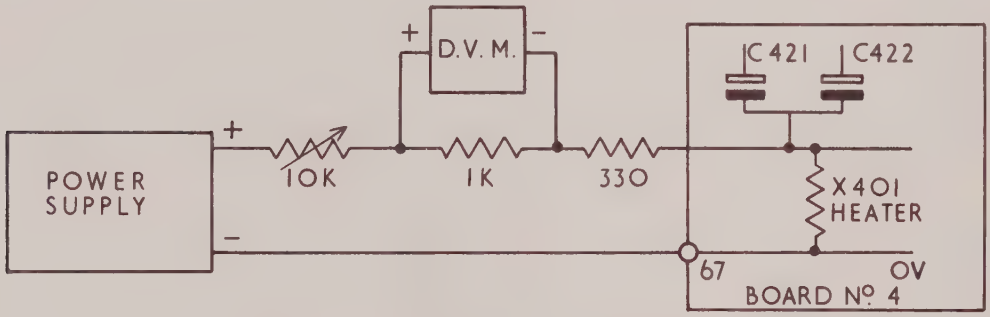


Fig. 7. Test Rig, 5mA Current Source.

(3) By monitoring the voltage drop across the close tolerance resistor R1 on a digital voltmeter, set the current to 5mA ± 0.05mA by adjustment of variable resistor RV1.
(4) Switch off the power supply driving the current source.
(5) On the VM 1484, set range selector to "1mV", set POWER switch to ON, and wait some 30 seconds for meter to settle.
(6) Switch on the power supply driving the current source.
(7) Connect digital voltmeter across R449, and adjust RV101 (board No. 1) for a digital voltmeter reading of 15V ± 100mV. If RV101 runs out of control, or the 15V setting is very near one end of its travel, turn RV101 fully counter-clockwise, and note the VM 1484 meter reading. Now turn RV101 in a clockwise direction until the VM 1484 meter reading has increased by 2% of f.s.d. (20μV). The digital voltmeter reading must now be less than 15.6V.

NOTE: If the VM 1484 meter response is erratic when adjusting RV101, clean that portion of the potentiometer track which will be used by turning the screw adjuster to and fro.

(8) Adjust RV203 (board No. 2) for a VM 1484 meter reading of 1mV (f.s.d.).

NOTE: If the VM 1484 meter response is erratic when adjusting RV203, clean that portion of the track which will be used by turning the screw adjuster to and fro.

(9) Switch off the power supply driving the current source.
(10) Set VM 1484 POWER switch to "off", and disconnect current source from X401 heater.
(11) Refit bottom screen over board No. 4.

Meter and D.V.M. Output Calibration.

8. All components are mounted on board No. 2 unless otherwise stated.

(1) Remove short from VM 1484 INPUT socket.
(2) Connect the thermocouple monitor unit (item(13) of test equipment) to the 50Ω termination (item (9)), and connect the termination to the VM 1484 INPUT socket.
(3) Connect a digital voltmeter (D.V.M. 1) to the VM 1484 D.V.M. sockets. Apply a 500c/s, 500mV r.m.s. approx. signal to the thermocouple monitor unit, and adjust the signal level for a reading of 500mV on the digital voltmeter.
(4) Connect a second digital voltmeter (D.V.M. 2) to the couple (output) of the thermocouple monitor unit, and note the reading on D.V.M. 2.

(5) Increase the signal frequency to 100kc/s, and adjust level to obtain the same reading on D.V.M. 2 as was noted in sub-para (4).
(6) Adjust capacitor C7 (located behind INPUT socket) for a reading of 500mV ± 1mV on D.V.M. 1.
(7) Disconnect thermocouple monitor unit from INPUT socket, set VM 1484 range selector to "100mV", and apply a 100mV r.m.s. signal at 2.5kc/s to the VM 1484 INPUT socket from the a.c. calibrator (item (8) of test equipment). Adjust RV207 for a VM 1484 meter reading of 100mV (f.s.d.).
(8) Adjust RV106 (board No. 1) for a D.V.M. 1 reading of 1V ± 1mV.
(9) Select, in turn, the listed VM 1484 ranges and with the appropriate input, adjust the appropriate control for a D.V.M. 1 reading of 1V ± 1mV.

RANGE	INPUT	CONTROL
1mV	1mV	RV203
10mV	10mV	RV205
1V	1V	RV209

(10) Select, in turn, the listed VM 1484 ranges, and with the appropriate input, adjust the appropriate control for a D.V.M. 1 reading of 948.7mV ± 1mV, checking in each case that the VM 1484 meter registers "3" ± 0.3%.

RANGE	INPUT	CONTROL
3mV	3mV	RV204
30mV	30mV	RV206
300mV	300mV	RV208

(11) Set the VM 1484 range selector to "100mV", and the a.c. calibrator output level to 10mV r.m.s. Wait for three minutes.
(12) Adjust RV103 (board No. 1) for a D.V.M. 1 reading of 100mV ± 1mV.
(13) Set a.c. calibrator output level to 100mV r.m.s., and re-adjust RV101 (board No. 1) for a D.V.M. 1 reading of 1V ± 1mV.
(14) Set a.c. calibrator output level to 1mV, and check that a D.V.M. 1 reading of 300mV ±5mV is obtained.
(15) Set VM 1484 range selector to "30mV", the a.c. calibrator output level to 30mV, and note the reading on D.V.M. 1.
(16) Connect the VM 1484 "30mV" CAL. socket to the VM 1484 INPUT socket, and adjust RV201 for a D.V.M. 1 reading equal to that obtained in sub-para. (15).
(17) Set VM 1484 range selector to "1V", the a.c. calibrator output level to 1V, and note the reading on D.V.M. 1.
(18) Connect the VM 1484 "1V" CAL. socket to the VM 1484 INPUT socket, and adjust RV 202 for a D.V.M. 1 reading equal to that obtained in sub-para. (17).

Gain Check and Temperature Compensation of Chopper Amplifier

9. All components are mounted on board No. 1 unless otherwise stated.

(1) Short-circuit resistor R144, connect an oscilloscope between VT107 emitter and pin 18 (0 volts), and check that the noise voltage measures approximately 400mV r.m.s. Remove short from R144.
(2) Connect oscilloscope between pins 14 and 18 (0 volts), and check that the multivibrator frequency is within ± 1kc/s of 5kc/s, and that the waveform mark/space ratio is approximately unity.
(3) Connect digital voltmeter between the junction of thermistor X101/RV102 and pin 18 (0 volts), and adjust RV102 for zero reading ± 20mV on the digital voltmeter.
(4) Select the "300mV" range on the VM1484 and connect the "30mV" CAL. socket to the INPUT socket. Connect digital voltmeter across the VM 1484 rear panel D.V.M. sockets, wait three minutes, and then adjust RV103 ("10%") for a digital voltmeter reading of 100mV ± 2mV.
(5) Place VM 1484 in an oven operating at a temperature 20°C above ambient, and allow time (approx. 60 min.) for instrument to attain new temperature. Note reading on digital voltmeter at the elevated temperature.

(6) Connect digital voltmeter between the junction of X101/RV102 and pin 18 (0 volts), and adjust RV102 for a digital voltmeter reading equal to that value given by the following equation:-

(D.V.M. reading in (5) - 100mV) x 440

For example:- D.V.M. reading in (5) 114mV

then V = (114-100) 440 = +6.16V

or, D.V.M. reading in (5) = 87mV.

then V = (87-100) 440 = -5.72V

(7) Reconnect digital voltmeter across the VM 1484 D.V.M. sockets, and readjust RV103 for a digital voltmeter reading of 100mV ± 1mV.
(8) Remove VM 1484 from oven, and check that after cooling, the digital voltmeter connected across the D.V.M. sockets again registers 100mV ± 6mV.
(9) Refit both case sections to VM 1484.

Bandwidth Checks

10. (1) Connect the thermocouple monitor unit output to the attenuator (item (7) of test equipment), and the attenuator via a 50Ω cable to the 50Ω termination. Connect the 50Ω termination to the VM 1484 INPUT socket.
(2) Connect sine-wave oscillator (item (2) of test equipment) output, set to 2.5kc/s, to the thermocouple monitor unit, and connect a digital voltmeter (D.V.M. 1) to the VM 1484 D.V.M. sockets, and a second digital voltmeter (D.V.M. 2) across the output of the thermocouple monitor unit.

(3) Set VM 1484 range selector to "1mV", and the attenuator to 56dB, and adjust the oscillator output level to obtain a reading of 1V ± 1mV on D.V.M. 1. Note the reading on D.V.M. 2.

NOTE: The test detailed in sub-paras. (4) and (5) following should be performed in the shortest possible time, so that the thermocouple monitor unit is maintained at a reasonably constant temperature. If this is not done, it will be necessary to repeat procedure detailed in sub-para. (3) to obtain a new valid reading on D.V.M. 2.

(4) Successively set the sine-wave oscillator output to the listed frequencies, for each frequency adjusting the oscillator output level to obtain the same reading on D.V.M. 2 as was noted in sub-para. (3). Note and record the reading on D.V.M. 1 for each frequency.
Oscillator Frequency:- 25, 40, 90, 500c/s, 10, 50, 100, 500kc/s.
(5) Repeat procedures detailed in sub-paras. (2) - (4) on the VM 1484 "10mV" and "100mV" ranges, with the attenuator set for 36dB and 16dB respectively.
(6) Set VM 1484 range selector to "1V", the attenuator to 0dB, and the oscillator output frequency to 2.5kc/s. Adjust oscillator output level for a D.V.M. 1 reading of 500mV ± 1mV. Note the reading on D.V.M. 2.
(7) Repeat procedure detailed in sub-para. (4), this time adjusting the oscillator output level for a D.V.M. 2 reading as was noted in sub-para. (6).
(8) Set VM 1484 range selector to "1mV", attenuator to 56dB, and oscillator output to 3V p-p amplitude at 50kc/s. Adjust oscillator output level for a D.V.M. 1 reading equal to that obtained at 50kc/s in sub-para. (4). Note the reading on D.V.M. 2.

NOTE: If the oscillator used in sub-paras. (1) - (7) does not operate up to 10Mc/s, substitute one that does for this and subsequent tests.

(9) Successively set the sine-wave oscillator output to the listed frequencies, for each frequency adjusting the oscillator output level to obtain the same reading on D.V.M. 2 as was noted in sub-para. (8). Note and record the reading on D.V.M. 1 for each frequency.
Oscillator Frequency:- 1, 2, 3, 4, 6, 10, Mc/s.
(10) Repeat procedures detailed in sub-paras. (8) and (9) on the VM 1484 "10mV" and "100mV"

ranges, with the attenuator set for 36dB and 16dB respectively.

(11) Set VM 1484 range selector to "1V", the attenuator to 0dB, and the oscillator output frequency to 50kc/s. Adjust oscillator output level for a D.V.M. 2 reading equal to that obtained at 50kc/s in sub-para. (7). Note the reading on D.V.M. 2.

(12) Repeat procedures detailed in sub-para. (9), this time adjusting the oscillator output level for a D.V.M. 2 reading equal to that obtained in sub-para. (11) at 50kc/s.

Power Supply Regulation

11. (1) Set VM 1484 POWER switch to "off", disconnect all test gear from VM 1484, and connect the mains input to the unit via the Variac (item (3) of test equipment).

(2) Connect the VM 1484 "30mV" CAL. socket to the VM 1484 INPUT socket, and apply power to VM 1484. Adjust Variac to swing the VM 1484 input voltage between 190 and 265V, checking that no change in meter reading occurs.

(3) Disconnect VM 1484 from mains supply, change fuse FS1 to 250mA SLO BLO, and set mains voltage selector panel to "115". .Set Variac to deliver 115V, and re-apply power to VM 1484. Adjust Variac to swing the VM 1484 input voltage between 95 and 128V, checking that no change in meter reading occurs.

(4) Remove power from VM 1484, return mains voltage selector panel to the "230" position, and change fuse FS1 back to 150mA SLO BLO.

FAULT-FINDING

General.

12. A suggested procedure for localising a fault is given in paragraph 13, together with typical values of circuit d.c. and a.c. voltage levels.

Fault-Finding Procedure

13. In the first instance check the levels of the +20, -20 and +85 volts supplies at the circuit points and to the limits set-down in paragraph (5), resetting if necessary in accordance with the directions given in the same paragraph. If no discrepancy is found, check the d.c. levels throughout the circuit against the typical values listed in Table 2. If this test is negative, check accuracy of the 30mV r.m.s. and 1V r.m.s. internally derived calibration signals against an external a.c. calibrator of suitable accuracy. Check calibration of the VM 1484 on the "30mV" and "1V" ranges by comparison with the appropriate internally-derived calibration signal. If an erroneous reading is still obtained, the fault must lie in the r.f., output, or chopper amplifiers carried on board Nos. 5, 4 and 1. Apply 30mV internally-derived calibration signal to the VM 1484 INPUT socket with the range selector set to "30mV", and with an a.c. millivoltmeter, check the a.c. levels throughout the r.f. amplifiers against the typical values listed in Table 3. If no marked discrepancies are noted, the fault must lie in the chopper amplifier, which fact can be confirmed by carrying-out the following test. Remove calibrating signal, short INPUT socket to chassis, and set range switch to "300mV". Apply 5mA d.c. current to the heater of thermocouple X401, employing the method detailed in paragraph 7, and check that a deflection of less than full-scale is obtained. With the chopper amplifier working correctly, full-scale deflection would be obtained.

Components Affecting Calibration.

General.

14. Virtually all components contained in the instrument have some bearing on its accuracy. It is therefore recommended, that after the replacement of any component, the measurement accuracy of the instrument, and the accuracy of the internally-derived 30mV and 1V calibrating signals, be checked against a suitable external standard. If, as a result of this check, a degradation of accuracy is revealed, the performance of the instrument can be returned to specification by carrying out the Setting-Up and Test Procedure detailed in paragraphs 3-11 inclusive.

TABLE 2

TYPICAL D.C. VOLTAGE LEVELS

BOARD No.	TEST POINT	VOLTAGE
1	VT103 emitter	4V
	VT105 emitter	5.4V
	VT107 emitter	11.2V
	VT115 emitter	3.5V
	Junction R133/R134	-10.4V
3	VT301 emitter	33V (200mV r.m.s.)
	VT304 base	7V
	VT312 base	1V
	VT312 collector	13.5V
	RV303 wiper	600mV
	⁂ VT307 emitter	33V (230mV r.m.s.)
	⁂ VT310 base	7V
	+ve terminal C308	180V (450mV r.m.s.)
	⁂ With respect to -20V rail, pin 54	
4	Input, pin 65	2V
	VT402 collector	5.3V
	VT403 collector	5.3V
	-ve terminal C407	2.7V
	VT405 collector	7.8V
	VT406 collector	8.5V
	VT407 emitter	7.8V
	VT409 collector	1V
	+ve terminal C418	10V
5	V501 anode (pin 2) with respect to +85V rail (board pin 78)	-9.6V
	Board pin 87	2V
	VT503 collector	5.3V
	VT504 collector	5.3V

NOTES:
(1) All voltages measured with respect to chassis (zero volts rail) except where otherwise stated.
(2) Bracketed figures after certain readings indicate ripple levels.

TABLE 3

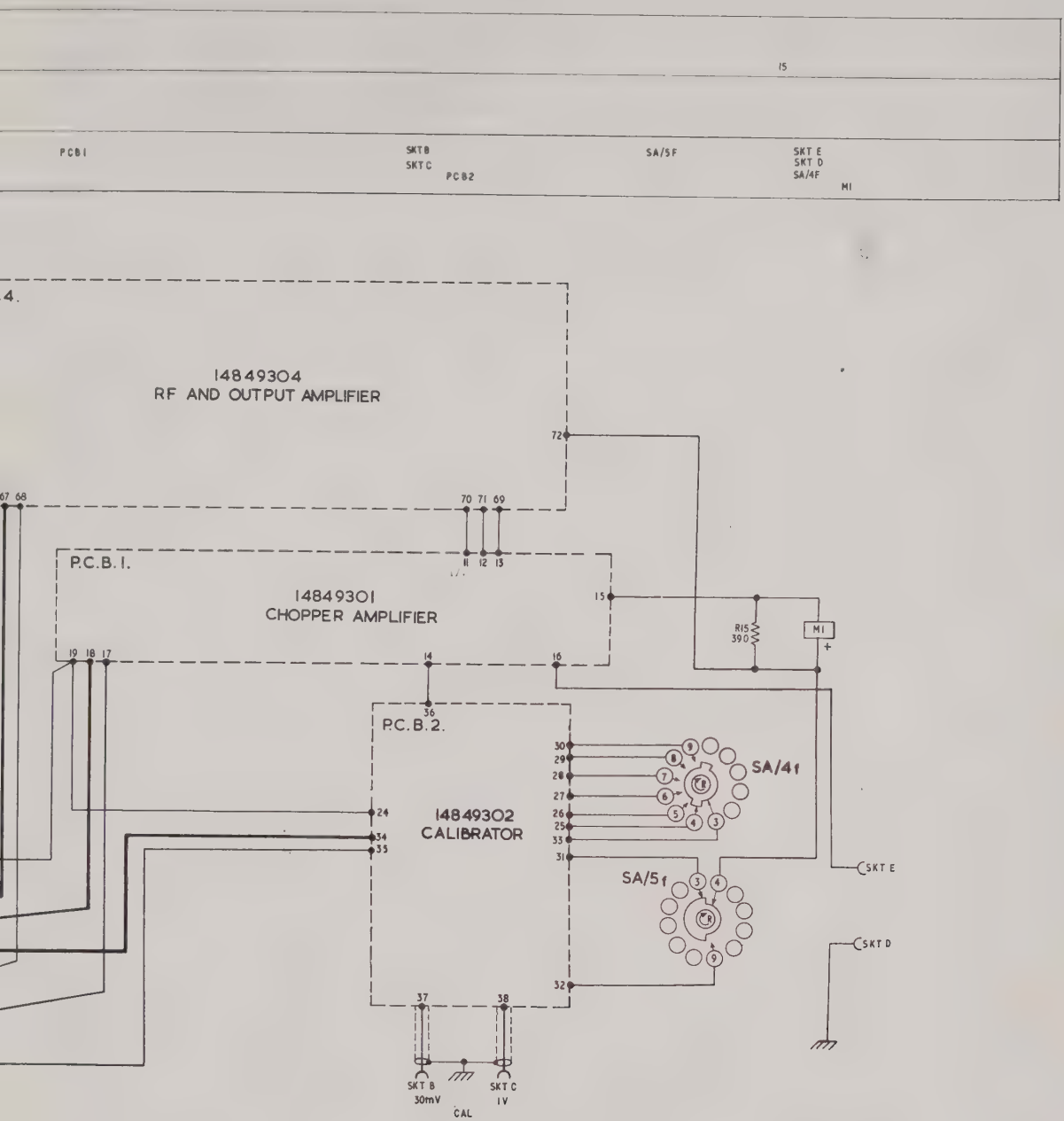
TYPICAL A.C. VOLTAGE LEVELS

BOARD No.	TEST POINT	VOLTAGE (R.M.S.)
4	Board pin 65	8.2mV
	VT402 emitter	7.6mV
	VT403 collector	72 mV
	VT405 emitter	69 mV
	VT407 emitter	390 mV
	-ve terminal C418	139 mV
	-ve terminal C421	450 mV
5	Board pin 79	30 mV
	Board pin 84	28.8mV
	Board pin 87	910 μV
	VT503 emitter	850 μV

NOTE:
All measurements taken with VM1484 range selector set to "30mV", and with the 30mV internal calibrating signal applied at the INPUT socket.

Replacement of Thermocouples

15. The thermocouples (X401, X402) are supplied by the manufacturers in matched pairs to a rigid specification. In the event of either thermocouple sustaining damage, it will be necessary to replace both components. Therefore, whenever thermocouple renewal is necessary, customers are advised to return the instrument to Solartron for repair.

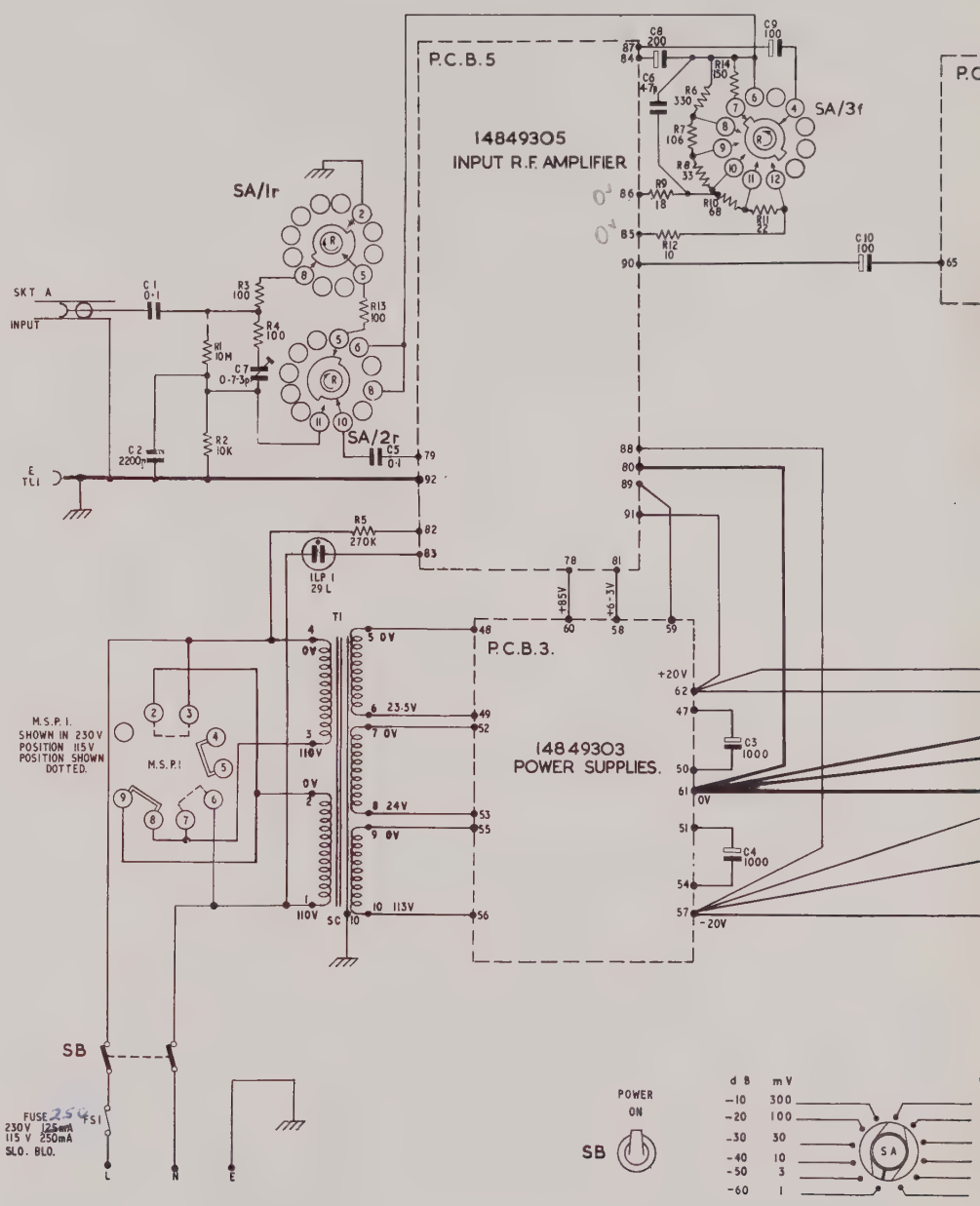


NOTE.

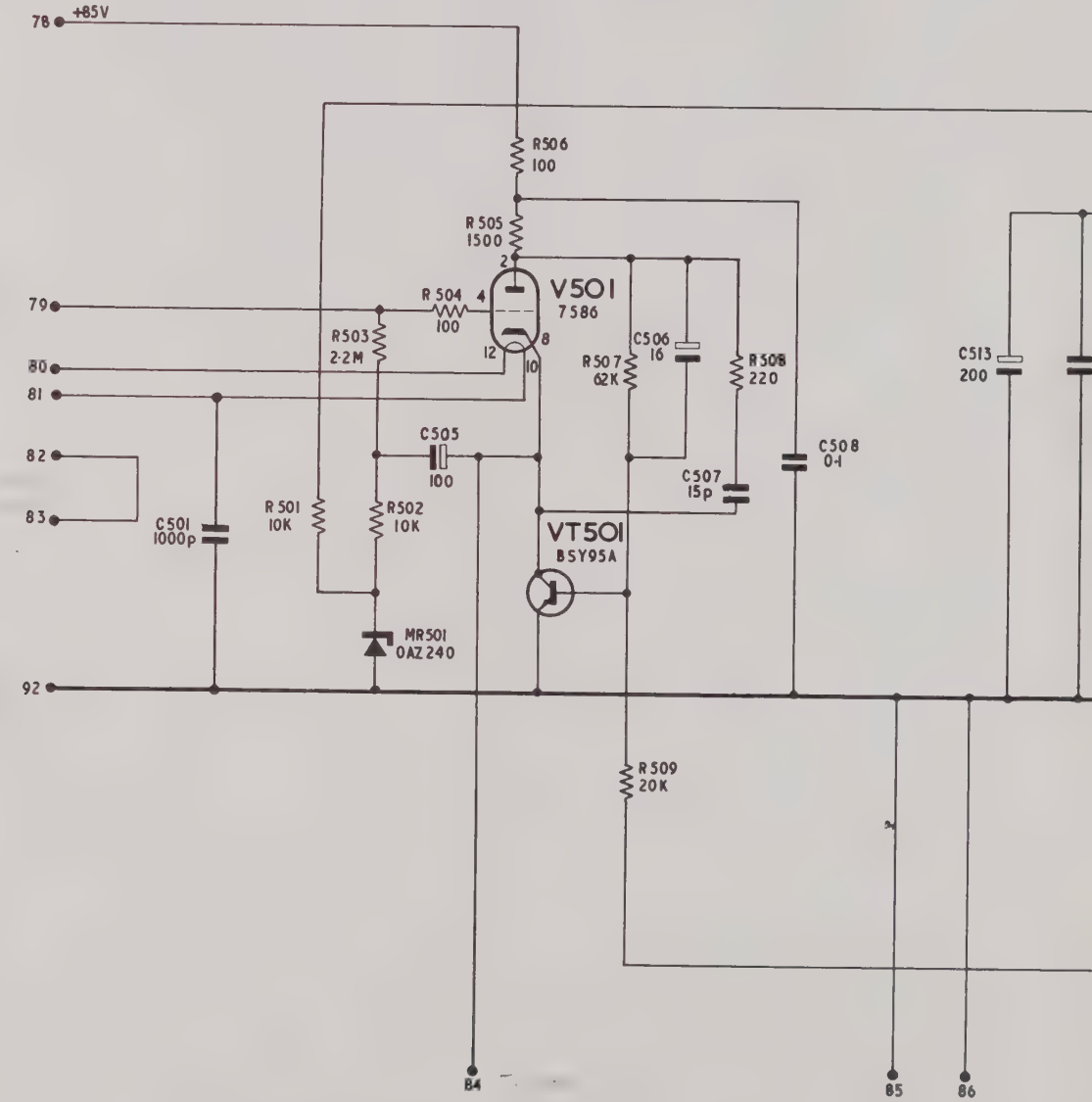
1. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.

Fig. 15. Circuit Diagram: Main Assembly VM1484.

R	1 2 3 4 5 13 6 7 9 8 10 12 14 11
C	1 2 7 5 6 8 9 3 4
MISC	SKT A TL1 M.S.P.1 SB FS1 ILP.1. T1 SA/1R SA/2R PCB5 PCB3 SA/3F PCB4



R	501 503 502 504 506 505 507 509 508
C	501 505 506 507 508 513
MISC	MR501 V501 VT501



1. * TO BE SELECTED ON TEST.
2. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARODS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
3. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW (R) OR ——►.

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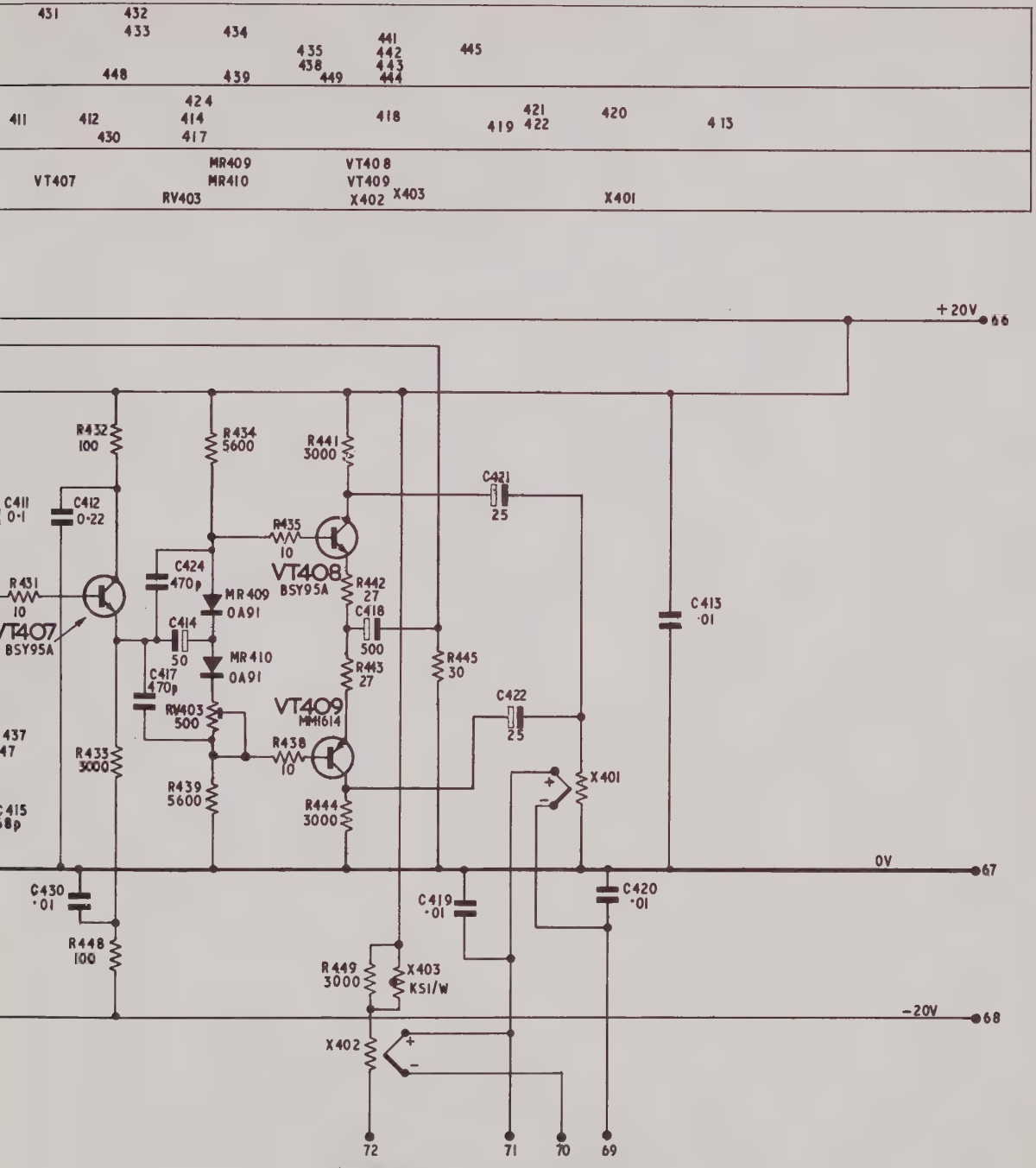

Fig. 17. Circuit Diagram: RF and Output Amplifiers.

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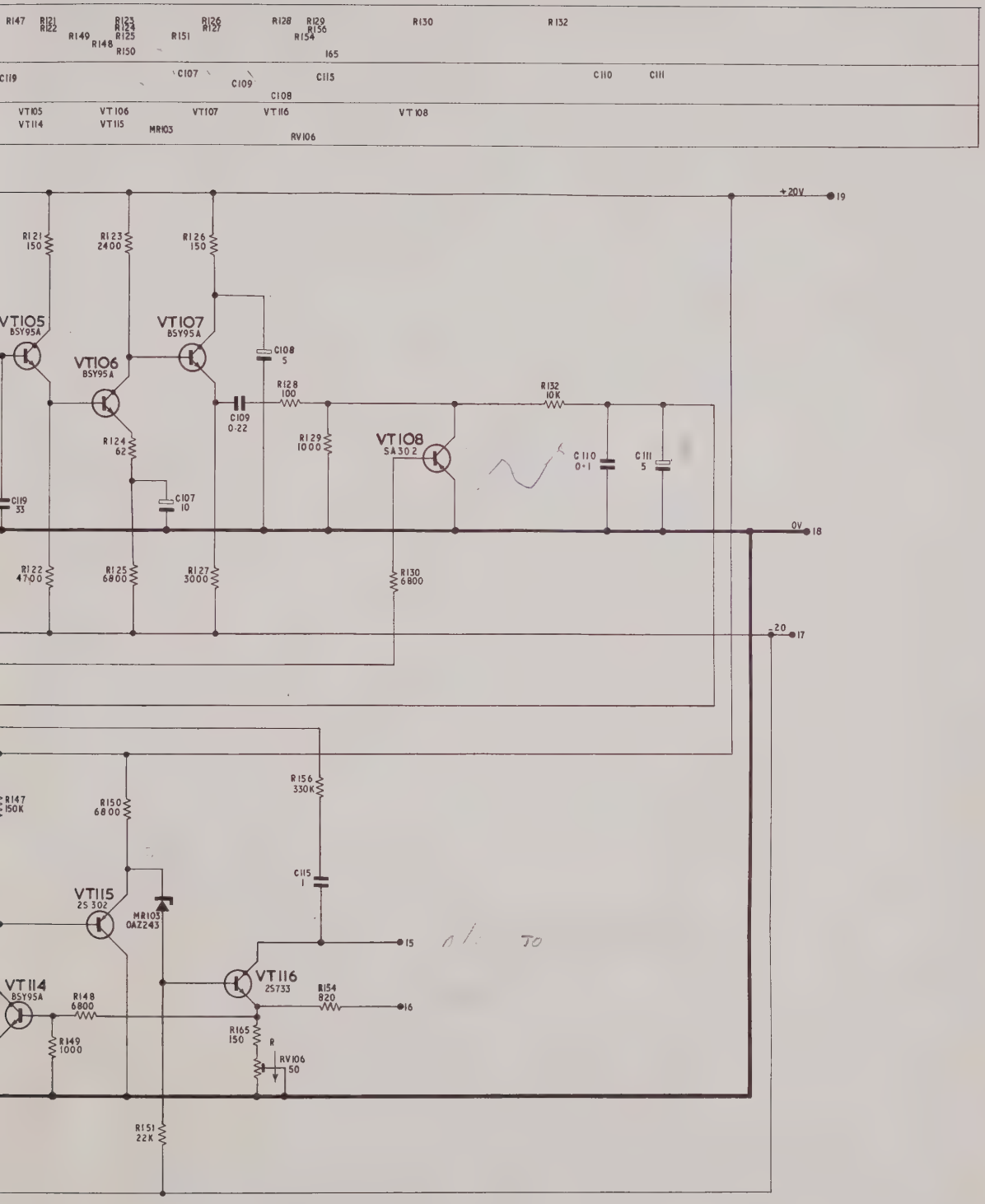

Fig. 18. Circuit Diagram: Chopper Amplifier.

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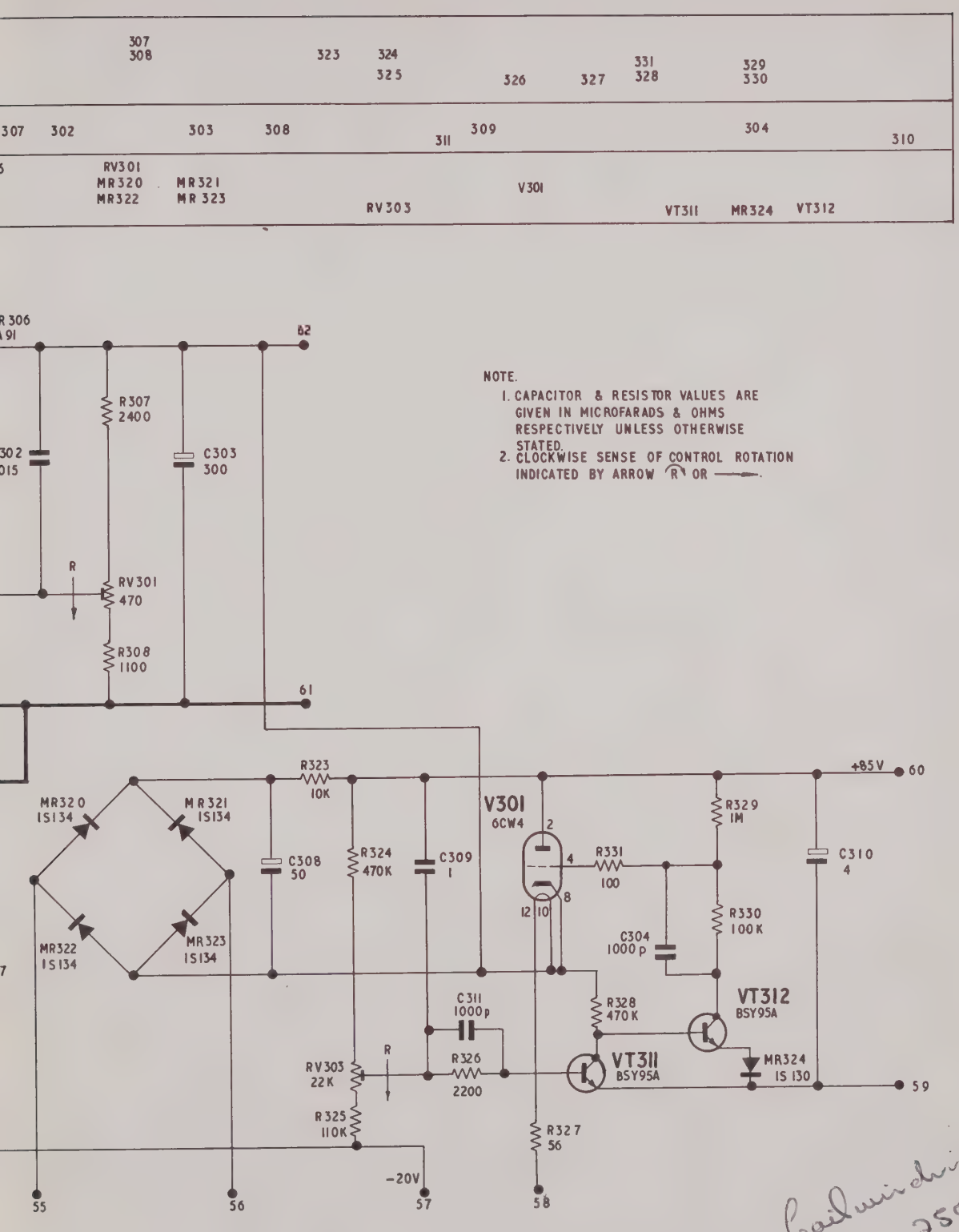
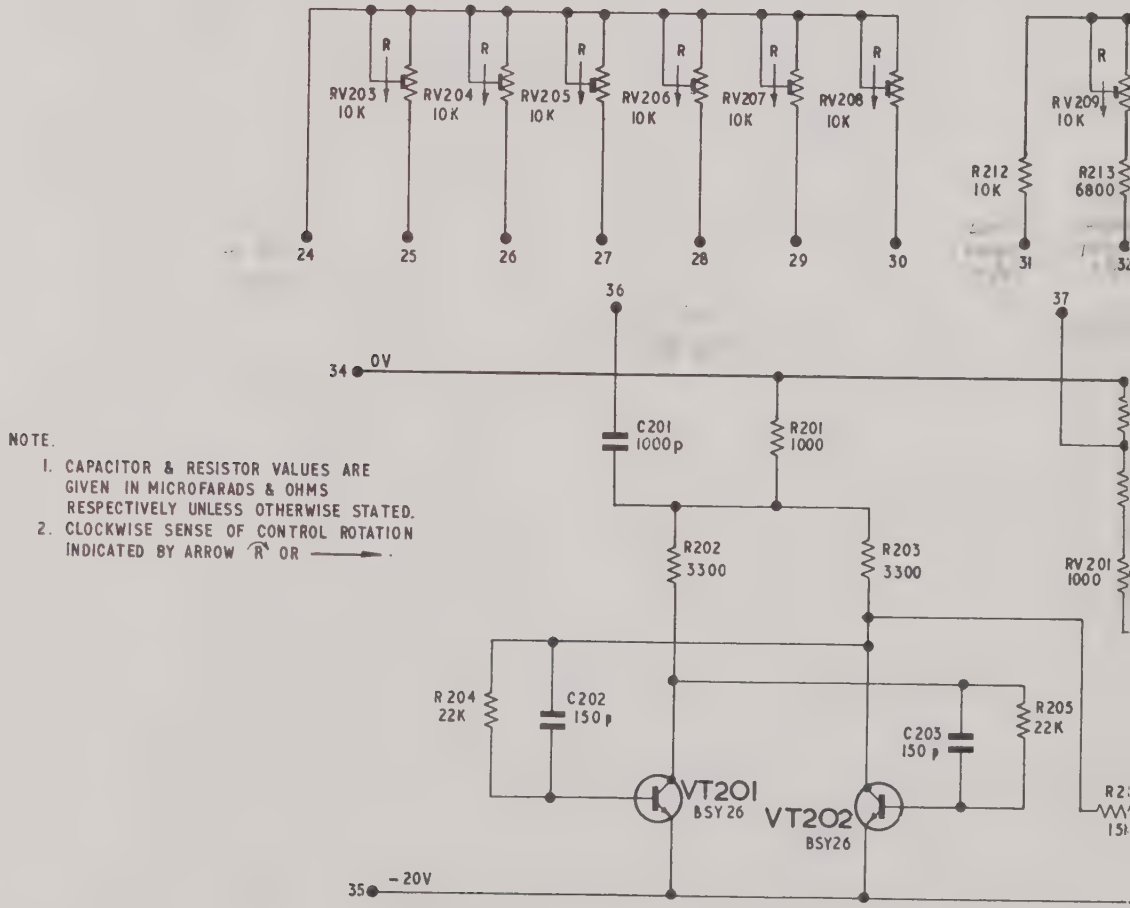


Coil winding
2507

Fig. 20. Circuit Diagram: Power Supplies.

R	204 202 201 203 212 205
C	202 201 203
MISC.	RV203 RV204 RV205 RV206 RV207 RV208 RV209 VT201 VT202



NOTE.

1. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
2. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW (R) OR ⟶.

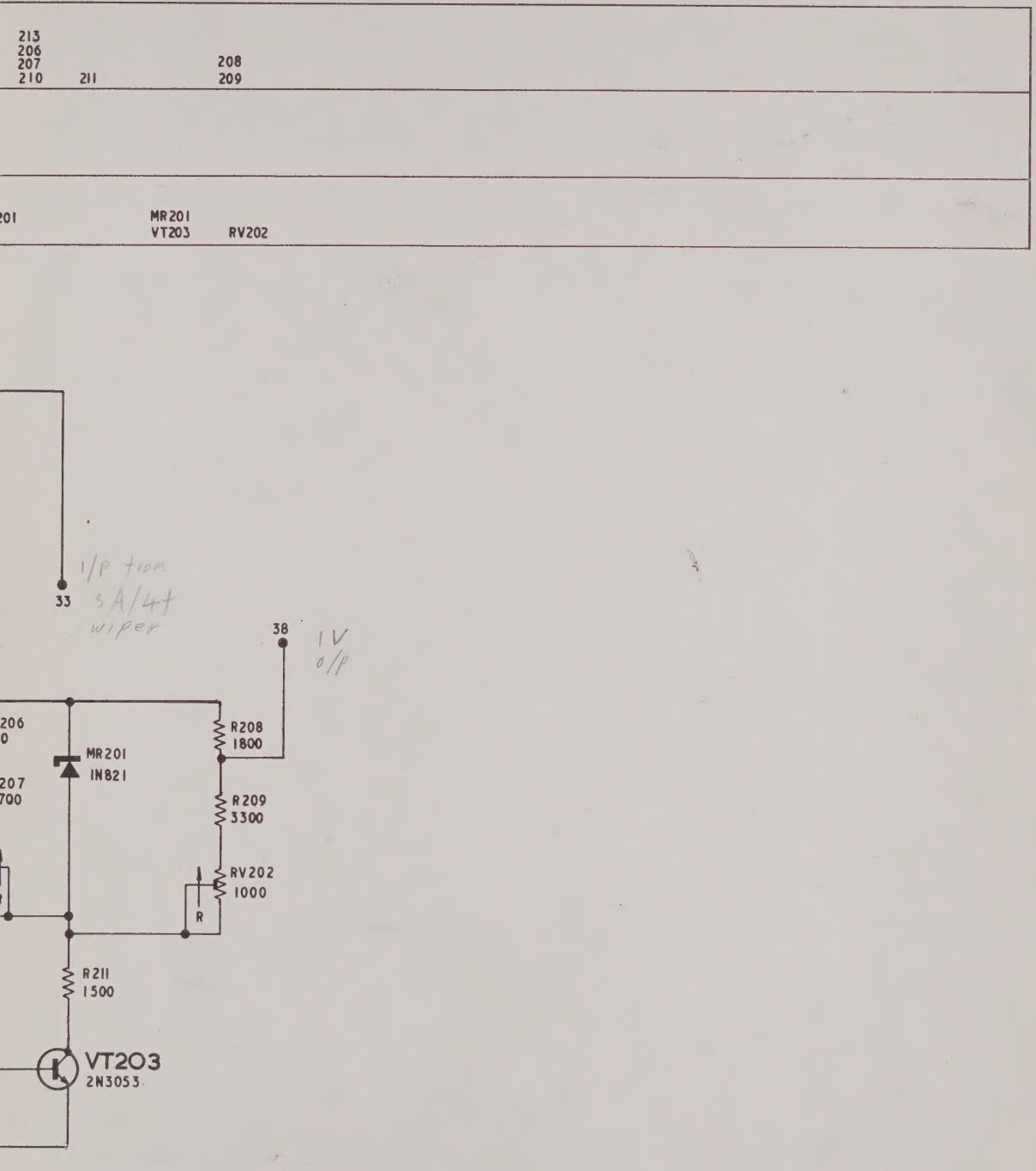


Fig. 19. Circuit Diagram: Calibrator.

MP MASTER
MA24437

The Solartron Electronic Group Ltd.
Victoria Road, Farnborough, Hants.

Telephone: Farnborough ~~3000~~ 44433 Telex: 85245 Solartron Fnbro. Cables: Solartron Farnborough.

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